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are, if not of circumpolar, at least of subarctic or boreal origin. From these facts we are led to accept the conclusions of Lesquereux and Gray that co-specific or congeneric forms occurring in California and Europe and Asia, are the remnants of a southward migration from polar tertiary lands during tertiary and even perhaps cretaceous times; and in proportion to the high antiquity of the migrations there have been changes and extinctions causing the present anomalies in the distribution of organized beings which are now so difficult to account for on any other hypothesis.

For this reason it is not improbable that those species of insects which are more or less cosmopolite (and independently so of human agency) are the most ancient, just as some forms taxonomically the most remote are remnants of earlier geological periods. For example, the curious anomalies in the geographical distribution of *Limulus*, the genus only occurring on the eastern coasts of Asia and North America, accord with its isolation from other crustacea. Geological extinction has gone hand in hand with geographical isolation. It was a common form in Europe in the jurassic period, and in the next lower (permian) period but one (the triassic intervening) we find other Merostomata and a few Trilobites.

We make these speculations hoping that much light will be thrown upon the subject by studies on the rich tertiary insect beds of the west, and of the fossil insects in the arctic tertiary and cretaceous formations. Until then we must regard all foundations for these hypotheses as laid by the fossil botanist.

ON THE STATUS OF ARISTOTLE IN SYSTEMATIC ZOOLOGY.

BY THEODORE GILL, M.D., PH. D.

SUCH extravagant claims have been urged in favor of the recognition of Aristotle as an exponent of classificatory science, and as a model meet to be followed by the naturalists of the rising generation, that it may be timely to inquire into the merits of such claims, and whether they are really justified by his works. In doing so we must, of course, in justice to the ancient author, exclude from con-

sideration the results of accumulation of data by various workers, which have culminated in the recognition of the valuation and subordination of groups now prevalent, and limit ourselves to the inquiry whether there was aught, either in the spirit or the method of inquiry exhibited in Aristotle's works, or in any of his conclusions, far in advance of his own age and transcending (as has been urged) even the fruits of the researches of Linné and later writers. And inasmuch as the mammals are the best known, and most familiar to the naturalist as well as layman, the treatment of the members of that class may be examined, and it may be regarded as tolerably certain that if ill fortune has resulted in their case, it has, to even a greater degree, in others: and, as a matter of fact, such has resulted in other cases, but the reader will have to take for granted that the writer has satisfied himself of the fact. If the statement should be gainsaid, he is prepared to prove the truth of the assertion; meanwhile, proof is only offered affecting the classification of the mammals. The references to the book, chapter, and paragraph where are found the assertions commented upon, will enable verification (or correction) to be readily made. The principal claims in behalf of Aristotle affecting the mammals are the following:—

1st. The complete and scientific recognition of the class as now limited.

2d. The recognition of relations based on scientific induction and knowledge of homologies.

3d. The recognition of natural groups (families, orders, etc.) as now understood.

4th. The appreciation of the principles of classification; or, in other words, the subordination of values of such groups.

These may be examined in the order enumerated.

1. **RECOGNITION OF THE CLASS.** It has been urged that the full recognition of the class of mammals was attained by Aristotle; that, in fact, "The Zootoka of Aristotle included the same outwardly diverse but organically similar beings which constitute the Mammalia of modern naturalists."*

It is quite true that all the mammals were recognized as Zootoka (or viviparous), but so were other animals, and the adjective was not restricted to the mammals. In reference to reproduction, Aristotle has simply remarked, as matters of ordinary observation,

*Owen (R.) On the classification. . . of the mammalia. . . 1859, p. 1.

that animals are viviparous, oviparous and vermiparous. Such a distribution would naturally occur to one who had observed a number of facts, but very little scientific knowledge would suffice to correct the erroneous first impression.

Further, among the viviparous animals are included man, the horse, the seal,* and others with hair; and among marine animals the cetaceans, but so are also the *Selachians* (I, iv, 1) and, in another chapter (I, vi, 2), the viper is added. He makes, it is true, a distinction between such as are *internally* viviparous and oviparous (I, iv, 2) for he had not conceived of the possibility of the truth embodied in the aphorism "*omne vivum ex ovo*" but there is no evidence that he had any conception of the significance of the character observed, or that if called upon to subordinate the groups of animals, he would have classed them otherwise than ordinary observers of the same facts would have done and, in numerous cases and with knowledge of the same facts, did afterwards: it is at least, an assumption which is even negated by other observations of Aristotle, and rendered improbable by our knowledge of the operations of the mind exhibited by others in the classification of facts.

If, on the one hand, Aristotle appears to recognize, in the statement that the Selache are viviparous fishes (VI, x, 1), that the Cetaceans are not fishes, but a peculiar group (I, vi, 1) like birds and fishes; on the other hand, by direct association of them with Selachians as viviparous aquatic animals (VI, xi, 4) and their contradistinction from viviparous animals with feet and from man, as well as from the oviparous fishes, he removes them to a still greater extent from the ordinary mammals† and raises a doubt what really were his ideas as to their relations.

2. RECOGNITION OF HOMOLOGIES.—Although recognizing homologies in a vague manner (I, i, 3, 4), as any one capable of thinking and expressing his thoughts must do to a greater or less extent, his appreciation rarely advanced much if at all beyond the popular views, and he frequently confounded the relations of true homology and analogy, putting, *e. g.*, in the same category, the relation of the nails and hoofs of ordinary quadrupeds and the nails of the

* The seal, in another place (where it is also said to have cartilaginous bones) (VI, xi, 3), was associated with the cetaceans, as were also the sawfish (Pristis) and *βοῖς* (Cetoptera?) (VI, xi, 1.)

† Oviparous vertebrates are interposed between the two categories.

human hand, and crabs' claws (I, i, 4). Deceived by the inclusion of the proximal joints of the members within the common abdominal integument and the elevation of the heel and carpus, in most mammals, he adopted the current view that all animals, except the elephant, differed from man in the contrary flexures of the limbs, having the joints of the fore limbs (really the carpus) directed forwards and those of the hind limbs (tarsus) directed backwards (II, i, 4). His observations of monkeys, which would have enabled him to add other exceptions to the elephants, were even forgotten for the time being in these "generalizations."*

A still more evident failure to appreciate correlation of structure is exhibited in the statement that the lion has no vertebræ, but only one bone in the neck (II, i, 1), and yet no one—certainly no one habituated to comparison of things—could look upon that animal without perceiving the likeness to the cat,† and it might also be supposed that the very movements of the beast, or natural deductions concerning them if it had not been seen alive, based on the knowledge of the necessities of animal life and animal mechanics, might have prevented the reception of such strange ideas.

3. APPRECIATION OF GROUPS.—Among the multifarious objects of which the sense of sight takes cognizance, there are many so much alike that they are at first naturally confounded; and intellectual acumen is exhibited, not in synthesis or the appreciation of the resemblances, but in analysis or perception of the differences: especially is this the case, when the like forms are contrasted with others; the differences are then still more lost sight of and overshadowed by the closer common bond coming into bolder relief in contrast with the unlike. For example, it requires no penetrating acumen to recognize man, the monkeys, the bats, the typical ruminants and the typical cetaceans as distinct forms existent in nature. But such are fair examples of the groups for the appreciation of which Aristotle has been so highly lauded,—groups which from their very nature in their integrity first appeal to the senses, and which only minute analysis enables the observer subsequently to differentiate into ultimate constituents.

4. SUBORDINATION OF GROUPS.—If, too, modifications of the

*In another place, he recognized the homologous relations of the members in man and the monkeys, remarking that both the arms and legs are flexed as in man, and curved towards each other. (II, v, 3.)

†Yet Aristotle does not seem to have recognized this relation, as he remarks that the lion's internal parts, when exposed, resemble those of a dog.

members are to be considered, it would be rather a person of peculiar idiosyncrasy whose attention would not be first arrested by the characters exhibited by man (biped), quadrupeds, and whales (fish-like and without hind limbs).

Equally probable would it be that, when examining the feet of quadrupeds, his attention would be first arrested by the differences seen in the hoofed and unguiculate mammals; and if, further, the former were studied, the cloven hoof of the ruminant, the solid one of the horse; and the divided one of the elephant would be equally likely to first attract attention. And yet these obvious points of structure are almost the only ones noticed by Aristotle. He made no attempt to coördinate them, to subordinate the groups so distinguished, or to assess a taxonomic valuation on characters or groups; in brief, there is no evidence of definite ideas of classification having occurred to him. It may, indeed, be well believed that some indistinct perception of system must have flashed upon the mind of such a man, but the impression was too undecided and intangible to be seized and embodied in a system.

Those groups which Aristotle recognized are the crude materials with which the naturalist has to deal. He was unacquainted even with the characters which furnish the criteria for classifying them, and to assign to him any definite views respecting their relationship is an anachronism and may involve a wrong to himself.

In fine, there is, so far as I can perceive, not the slightest evidence of any recognition of what is now understood by classification in any of the extant treatises of Aristotle on animals, and the systems framed to embody his generalizations have been constructed from isolated sentences wrested from their context and simply reflect the framer's notions or his ideas as to what Aristotle might have supposed.

And, as a hearty admirer of the great philosopher (more excellent in intellectual than in physical science), I may claim a right to protest against systems (like that, *e. g.*, published by Macleay) which have been fathered upon him; I may assume that had his attention ever been challenged, he might have better appreciated the relations existing between the groups which he, in common with daily observers, perceived.

Careful and repeated perusal of Aristotle's biological treatises have, in fact, failed to convey to the writer any impression save

that he was a tolerably good observer and compiler, and surpassed ordinary men, perhaps, in ability to embody in words the results of his observations of various disconnected facts. There is, however, no coördination of the facts observed, no valuation, and no subordination which would entitle his observations to be considered as a body of scientific facts or doctrine. The materials for science exist indeed, but in a very crude and imperfect condition. Commendation of his work as a model of scientific treatment betrays a phase of mind and appreciation which is not readily comprehensible, and has only found expression in vague eulogy without proffer of the proof or basis for the encomiums. It need only be added that in this opinion I essentially agree with some of the best qualified students of the works of the great Stagyræ. Of these, I need only mention especially the several treatises of Dr. Whewell,* the great master of Trinity college; Prof. Carl Sundevall† who has published a commentary on several of the classes treated of by Aristotle; and Mr. George Henry Lewes‡, who has devoted a special work to an examination of Aristotle's various treatises. The verdicts of these gentlemen are pertinent and amply justified, I think, by the facts. The same can scarcely be said of the censorious criticism of the Grammarian of the Deipnosophistæ,§ or of the illustrious advocate of the inductive method||, but even their judgments, or at least that of the last, are the natural result of antagonism to the opposite extreme.

At a future time, I may perhaps publish an analysis of the four capital propositions ascribed by Cuvier to Aristotle.

*Whewell (William). History of the inductive Sciences, from the earliest to the present time. . . . [Various editions, book xvi, chap. 6.]

——— [On the Philosophy of discovery, chapters historical and critical . . . London: John W. Parker and Son. . . . 1860. (pp. 23-78.)]

†Sundevall (Carl Johan) Ett försök att bestämma de af Aristoteles omtalade Djurarterna. . . . Första afdelningen: luftandande djur, eller Klasserna: Däggdjur, Föglar, Reptiler och Insekter med Arachnider . . . Stockholm . . . 1862 . . . [4to, 148 pp.] < Kongliga svenska Vetenskaps-Akademiens Handlingar. Ny följd. iv, 1864.

——— Die Thierarten des Aristoteles von den Klassen der Säugethiere, Vögel, Reptilien und Insekten . . . Übersetzung aus dem Schwedischen.—Stockholm, 1863, bei Samson Wallin. [8vo, 242 pp.] A translation, edited by the author, of the preceding.

‡Lewes (George Henry). Aristotle: a chapter from the history of science, including analyses of Aristotle's scientific writings. . . . London: Smith, Elder and Co.; . . . 1864.] 8vo, x, [1] 404 pp.] (see, especially, pp. 269-279.)

§Athenæus. Deipnosophistæ, Book viii, c. 47-50.

||Bacon (Francis Lord). Novum Organon, [various editions, Pars I, Aph. lxiii,] etc.